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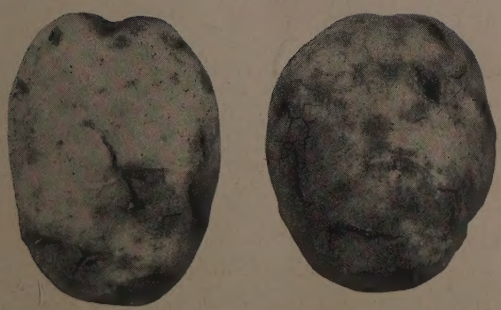
BACTERIAL WILT AND SOFT ROT OF THE POTATO IN MAINE



Tubers showing external symptoms of bacterial wilt and soft rot. The two tubers are of the Green Mountain variety.

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AGRICULTURAL EXPERIMENT STATION
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BULLETIN 396

BACTERIAL WILT AND SOFT ROT OF THE POTATO IN MAINE

REINER BONDE

INTRODUCTION

The bacterial wilt and soft rot of the potato recently described from Maine (3) and Canada (1, 2, and 9) is becoming of major importance and every effort should be made to prevent its spread. This disease was first found in Maine in 1932 in a field where 30 per cent of the plants were affected and 20 per cent of the tubers showed decay. Bacterial wilt and soft rot did not appear to be of much consequence in Maine until 1937, when an epidemic of it occurred. At that time 310 acres, or 28 per cent of the acreage, of the Spaulding Rose variety entered for seed certification was rejected because of bacterial wilt and soft rot. The disease was even more serious in 1938 when 749 acres was rejected from certification because of bacterial wilt.[1]

Wilt and soft rot is not limited to Maine and Canada. It has appeared in Pennsylvania[2] and Florida (5) in fields planted with seed stocks originating from Maine. Diseases of a similar nature have appeared recently in Wyoming (6), and Metzger (7) in Colorado has described a potato malady which possibly may be the same as that described from Maine.

According to Burkholder (4) the pathogen of the Maine disease is similar to that of bacterial tuber ring-rot described in Germany by Spieckermann and Kotthoff (10) and by Stapp (11), and is caused by *Phytomonas sepedonica* (Spieckermann and Kotthoff) Bergey *et al.*

DESCRIPTION OF THE DISEASE

The foliage symptoms of bacterial wilt and soft rot generally do not become evident until quite late in the growing season. Plants

[1] Data obtained from E. L. Newdick in charge of seed potato certification in Maine.

[2] According to a statement by O. D. Burke in The Plant Disease Reporter 22:444. 1938.

from infected seed tubers planted in 1937 and 1938 had not shown symptoms by July 25. Only very slight symptoms of wilting were present in a few plants ten days later and the disease was not distinctly apparent until the middle of August.

Field observations made in Maine since 1932 show that the disease can be detected in commercial fields beginning about August 10 or 15 and becomes more prevalent as the season progresses. The late appearance of the symptoms, at a time when the foliage has begun to mature and when late blight and early blight have often become prevalent, probably often causes this disease to escape notice when present.

The first evidence of the disease in the field is a slight wilting of the leaves and stalks. (Fig. 38.) The wilting may be present

FIG. 38. Green Mountain potato plant showing typical wilt symptoms in the field. Note healthy stalk on the left.

in the whole plant or in individual stalks and is most evident when the sun is bright and dry weather prevails. The affected leaves often are mottled and chlorotic and sometimes are pale green. The chlorotic leaves develop marginal necrosis and gradually die. Sometimes the disease completely kills the plant. (Fig. 39.) In some

FIG. 39. Spaulding Rose potato plants showing typical wilt symptoms in the field. The plant on the left is slightly affected as evidenced by some chlorosis in the upper leaves and a slight wilting in some of the leaves. The one on the right has an advanced stage of the disease.

cases the underground parts of the small stalks of infected plants develop longitudinal cracks. The vascular bundles of the wilted plants generally appear normal in color.

The diseased plants may be uniformly scattered about the field but more often appear most abundant in certain rows, indicating that some batches of a seed lot contain more of the disease than others of the same lot.

The condition of the tubers from the diseased plants may vary from no apparent infection to complete disintegration by the disease. Some affected tubers have darkened discolorations beneath the periderm which often occur in the region near the eyes. The tubers from affected plants, if harvested before secondary rots have destroyed the outer part of the tuber, often show characteristic cracks which extend merely to the vascular ring. (Fig. 40.)

An early stage of decay affects chiefly the vascular ring. This decaying portion appears yellowish white and crumbly or cheesy.

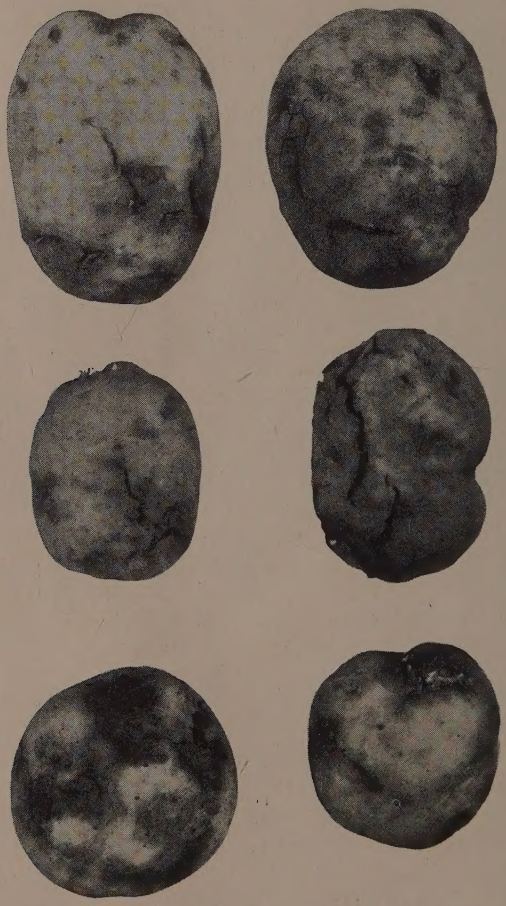

FIG. 40. Tubers showing external symptoms of bacterial wilt and soft rot. The four upper tubers show typical cracking in the Green Mountain variety. The two lower tubers show darkened discolorations beneath the periderm in the Irish Cobbler variety.

The cortex and outer storage parenchyma may separate distinctly from the vascular ring, causing a "ring rot" appearance in cross section. (Fig. 41.) The decay, probably because of secondary

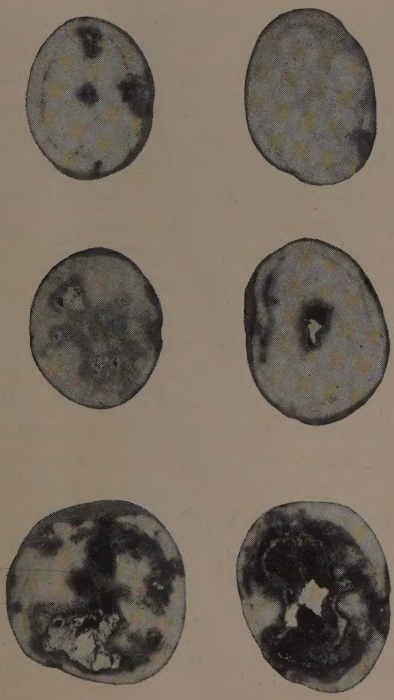

Fig. 41. Cut tubers showing different stages of vascular discoloration and decay caused by bacterial wilt and soft rot.

pathogens, spreads rapidly from the vascular ring and soon affects the whole tuber. The entire center of the tuber may disintegrate, leaving a mere shell. These hollow tubers, in an advanced stage of the malady, are found frequently in bins of potatoes from affected fields, and are more common in the bin than in the field. In the field the more common form of advanced decay is a slimy soft rot.

Economic Losses from Bacterial Wilt and Soft Rot in Maine

The amount of bacterial wilt and soft rot occurring in Maine potato fields has varied from a trace to enough to affect 80 per

cent of the plants visibly. Fields with from 10 to 20 per cent infected plants have been quite common and a few have had from 50 to 80 per cent of the crop affected. The amount of crop rotted by the disease likewise has varied from an occasional diseased tuber to approximately one-third of the crop in some fields.

Bins of potatoes from badly affected fields show considerable decay in storage resulting in many rot contaminated tubers. Some of the tubers may break down in the sacks and containers during shipment which necessitates regrading and repacking.

Certain certified seed potato growers have lost most heavily from wilt and soft rot. These growers have suffered not only from lowered yields but from reduced market prices resulting from the failure of their fields to receive certification for seed purposes. In the summer of 1938, with seed stock relatively scarce, table stock sold for approximately $1.00 less per barrel (165 lbs.) than did certified seed. The loss sustained by growers of certified seed potatoes in Aroostook County because of failure in certification and a consequent reduction in the market price was estimated at approximately $32,000 in 1937 and nearly $80,000 in 1938. Fortunately for the prospects of control, the losses from wilt and soft rot have been restricted to relatively few growers.

NONPERSISTENCE OF BACTERIAL WILT AND SOFT ROT IN THE SOIL

It is of great importance to learn whether the wilt disease is soil borne. This problem has been given some attention in Maine. Healthy seed potatoes have been planted each year since 1934 in soil which the previous season had produced a diseased crop. The number of these plots that were grown each season has varied from two to eight. In no case has there been evidence that the disease was carried over the winter in the soil.[3]

The results secured by farmers support the above evidence that bacterial wilt and soft rot is not soil borne. No disease has resulted in Maine from planting fields that previously produced a crop having wilt, provided the seed tubers were healthy. All instances where infection has occurred can be attributed to other methods of spread than by contamination from the soil.

[3] The tubers from these plots have not been grown the second generation, excepting in a few cases. It is intended to do this in all future tests of this nature.

TUBER PERPETUATION OF BACTERIAL WILT AND SOFT ROT

It was shown that the disease is perpetuated more or less in the tubers from wilted plants (3). In 1936, 90 per cent of the progeny from wilted hills of 1935 developed the disease. The amount of wilt occurring in plants grown in 1937 from tubers taken from wilted hills in 1936 is summarized in Table 1. These results show further that bacterial wilt is seed borne, that many plants infected from the seed may not show wilt symptoms though they produce diseased tubers, and that a high percentage of the tubers from the progeny of affected plants may develop disease.

TABLE 1

Bacterial wilt and soft rot resulting in 1937 from planting seed tubers harvested from diseased plants in 1936

Variety	No. tubers planted	Percentage diseased	
		Plants	Tubers
Green Mountain	65	10.8	53.8
Ditto	52	3.8	61.8
Ditto	150	4.1	68.0
Irish Cobbler	40	5.0	5.0

RAPID INCREASE OF THE DISEASE IN THE FIELD

The amount of bacterial wilt and soft rot present in seed stocks may increase with great rapidity. Farmers, in most cases, have been quite reluctant to discard their diseased seed stocks, provided only small percentages of wilt were present, the belief being that it was not tuber borne or would increase very little. These farmers have been greatly disappointed whenever the crop grown from their slightly infected seed stock contained a large amount of disease the following year. Some typical examples showing the increase in the amount of the wilt disease are shown in Table 2.

The data shown in Table 2 are not extreme cases of disease spread. In 1938, thirty-six fields were rejected from certification because of the presence of wilt. All of these fields originated from seed stocks that had been carefully inspected for wilt the previous year and given a clean reading. It is apparent that the disease could

TABLE 2

*Increase in wilt and soft rot in some stocks of seed potatoes**

Seed lot	Amount of disease	
	1936	1937
		%
1	None noted†	15 to 45[1]
2	2 hills in 30 acres noted	1 to 20[2]
3	4 hills in 5 acres noted	7 to 30[3]
4	Trace	40 to 80[1]
5	None noted	15 to 20[1]
6	Trace	0.4
7	Trace	1 to 2
8	24%	70
9	8%	25

* These are some samples selected to show the rapidity with which the disease may spread in Aroostook County, Maine.

† This stock came from a tuber unit plot in 1935. The plot was free of disease.

[1] Variation in different parts of the same field.

[2] Variation from uncut to cut seed.

[3] Variation in different fields.

not have been present in very large amounts although it is quite likely that traces were present. According to observations made by the writer, a seed stock can contract a mere trace of disease the first year. Such a trace could easily be missed even with tuber by tuber examination. The following year this trace has increased to 1 or 2 per cent, and the third year the disease may be present to the extent that it materially injures the crop.

The question naturally arises as to whether or not the certification service is justified in rejecting for certification lots of seed having small percentages of this disease. The data in Table 2 show that a relatively small amount of infection may be increased greatly in the crop the following year. Also, the writer has observed potato fields in Maine with mere traces of wilt. Seed from these fields, when planted in Florida, produced large losses. It is true that in some cases these lots of seed produced very little disease and gave good crops. However, in others the disease was present in large amounts, causing large losses and a great deal of dissatisfaction. One lot of seed which had only a trace of wilt in Maine developed from 8 to 30 per cent wilted plants in Florida.[4]

[4] Dr. A. H. Eddins, Plant Pathologist at Hastings, Florida, estimated that the loss from bacterial wilt in the Hastings area was approximately 5 per cent of the crop in 1937 (5).

Dissemination of Bacterial Wilt in the Field

Some growers are of the opinion that this wilt is disseminated in the field. This viewpoint was so general that the writer began to obtain information on this phase of the problem. It is apparent that control measures will be more difficult if the disease is disseminated in the field from affected plants. During the years from 1934 to 1938, inclusive, samples were harvested from healthy stocks at different distances from sources of infection. These samples were planted the following year and the amount of wilt recorded.

The data from these studies are summarized in Table 3. It is to be noted that a relatively high percentage of the plants grown in close proximity to the wilted plants contracted the disease. The infection did not appear to spread extensively beyond the first row. More work is needed to determine the distances that the disease may be carried under field conditions.

It should be noted that in 1938 the healthy hills consisted of the Green Mountain, Irish Cobbler, and Chippewa varieties while the adjacent diseased hills consisted of the Spaulding Rose variety. The use of these particular varieties in this way was to prevent mixing the white-skinned tubers from the healthy test plants with the pink-skinned tubers of the plants that served as sources of infection.

The writer is not prepared to state definitely the method by which the wilt disease was disseminated. The data prove, however, that spread does occur under field conditions in Maine.

Field data indicate that the spread in the field occurs more extensively down a hillside slope. In 1938 diseased tubers of the Spaulding Rose variety were planted on a hillside slope with healthy Green Mountain tubers planted in the same rows both above and below the source of infection. Current season symptoms of the disease occurred in four instances in tubers from plants grown below the diseased plants and none appeared in plants grown in the soil located above the source of the disease.

Healthy and diseased tubers were planted in the same pots and grown under greenhouse conditions free from insects. One plant of four contracted the disease in this test. These data suggest that the bacterial wilt may be disseminated by soil water.

TABLE 3

Percentage of bacterial wilt and soft rot contracted under field conditions in Maine by healthy plants grown different distances from stocks having the disease

Year	Field No.	Variety	Proximity to wilt disease	No. tubers selected	Hills with wilt or rot
1934	1	Katahdin	Field adjacent to Green Mountain field with 30% wilt	100	5%
	2	Irish Cobbler	Ditto	100	2%
	3	Green Mountain (tuber unit seed plot)	Field adjacent to Green Mountain field with 20% wilt	Seed for a 2-acre field	Trace*
1935	1	Green Mountain	Tubers from healthy hills each adjacent to a hill showing wilt symptoms	191	4.2%
	2	Ditto	Ditto	207	21.3%
	3	Ditto	Ditto	172	9.9%
	4	Irish Cobbler	Tubers from healthy hills each adjacent to a hill showing wilt symptoms	169	1.2%
1937	1	Green Mountain	Tubers from healthy hills in one row† adjacent to Spaulding Rose plants with 30% wilt	94	24.4%
			As above but 8 rows distant from diseased Spaulding Rose plants	204	None
			As above but 23 rows distant from diseased Spaulding Rose plants	243	None
	2	Ditto	Tubers from healthy hills in one row adjacent to Spaulding Rose plants with 20% wilt	250	4.8%
	3	Katahdin	Tubers from healthy hills in one row adjacent to Spaulding Rose plants with 23% wilt	126	None
			As above but 15 rows distant from diseased Spaulding Rose plants	188	Trace
	4	Green Mountain	Tubers from healthy hills each adjacent to a hill showing symptoms	253	11.8%
	5	Ditto	Ditto	133	16.5%
			Tubers from healthy hills that were in field having wilt-diseased hills but were not adjacent to diseased hills	128	11.7%
	6	Ditto	Tubers from healthy hills each adjacent to a hill with wilt. Harvested August 28	64	None
		Ditto	Tubers from healthy hills each adjacent to a hill with wilt. Harvested September 8	58	Trace
	7	Irish Cobbler	Tubers from healthy hills 15 to 24 rows distant from Spaulding Rose plants with 20% wilt	259	None

TABLE 3—(Concluded)

Year	Field No.	Variety	Proximity to wilt disease	No. tubers selected	Hills with wilt or rot
1938	1	Green Mountain	Healthy hills each adjacent to a Spaulding Rose hill with wilt	200	Trace‡
	2	Irish Cobbler	Ditto	200	Trace‡
	3	Green Mountain	Ditto	12	25%
	4	Chippewa	Ditto	12	25%

* This stock showed from a trace to 50 per cent disease, in different parts, the second year removed from seed plot.
† Rows are nearly 3 feet apart.
‡ A few of the healthy plants grown adjacent to the wilted plants showed current season symptoms. It is expected that more disease will develop in the progeny.

BACTERIAL WILT AND SOFT ROT DISSEMINATION BY CONTAMINATION OF THE SEED STOCK

The observation that bacterial wilt often increased in alarming amounts under field conditions suggested that contamination of the seed stocks was a possible method of spread. A series of experiments were conducted in the greenhouse and in the field to test this theory.

The different tests and the results that were obtained are given in Table 4. It may be noted that a high percentage of infection occurred when freshly cut seed pieces were contaminated and planted immediately in moist soil. There is some evidence that there is a reduction in the amount of infection if the cut seed is allowed to become dried before being planted.

A high percentage of the tubers became infected when the active inoculum was introduced into the freshly wounded vascular system prior to storage in the fall. Infection resulted also when freshly bruised tubers were contaminated and then placed in storage. The causal organism remained viable throughout the winter in the tubers inoculated through bruises and these tubers developed wilted plants.

These results show that the disease may result from contamination of the seed stock, either at the time of storage or when the seed is being cut. It should be noted that very little infection occurred if the contaminated seed tubers were not bruised or cut.

The data in Table 4 also indicate that the badly disintegrated material which resulted from the decay of diseased tubers had lost its infectiousness and was not an effective source of inoculum. This

indicates that the viable inoculum must come from the less severely diseased tubers. The yellowish, crumbly material associated with the diseased vascular system of the tubers serves as a virulent source of inoculum.

TABLE 4

Bacterial wilt and soft rot in Green Mountains resulting from contamination of seed stock from affected tubers

Place done	Treatment of seed stock	No. seed pieces planted	Hills with wilt or rot
			%
Greenhouse	Freshly cut seed pieces contaminated with decay from diseased tubers. Planted immediately in moist soil	25	80
Ditto	As above but seed pieces not planted until one day later	25	40
Field	Freshly cut seed pieces contaminated with decay from diseased tubers and planted immediately in moist soil	100	60
Ditto	As above but seed pieces contaminated with disintegrated material from diseased tubers*	194	None
Ditto	Freshly cut seed pieces covered in row with disintegrated material from affected tubers*	50	None
Ditto	Stem ends removed from healthy tubers on October 8, 1937, and wounds contaminated with decay from diseased tubers. Stored in bin and planted following spring	213	33.8 (also 21.1 more possibly infected)
Ditto	Healthy tubers bruised and contaminated with decay from affected tubers October 8, 1937. Stored in bin and planted following spring	171	7.6
Ditto	Healthy tubers contaminated with decay from diseased tubers October 8, 1937, but not bruised	100	1.0

* Badly affected tubers were stored in a barrel throughout the winter. These tubers became completely disintegrated as individuals, leaving only a mass of wet, rotted tissue.

BACTERIAL WILT TRANSMITTED BY THE SEED-CUTTING KNIFE

The fact that bacterial wilt and soft rot is readily transmitted by contamination of the seed pieces or of the seed tubers with affected tubers made it seem apparent that the disease might be disseminated also by the seed-cutting knife. The possibility of transmission with the seed-cutting knife was tested by experiments

conducted in the greenhouse and in the field. The knife was contaminated by cutting through a diseased tuber and then was used immediately to remove a seed piece from a healthy tuber. The knife was recontaminated before each healthy seed piece was severed from the seed tuber. The seed pieces contaminated in this manner were planted in moist soil and the plants and tubers that resulted were examined the following fall for symptoms of bacterial wilt and soft rot. The data from these preliminary tests are recorded in Table 5.

The data recorded in Table 5 confirm those of Racicot and Saville (8) in their indication that the seed-cutting knife may be an important factor in the dissemination of the disease. It should be noted that allowing the seed pieces to be quickly dried immediately after being cut reduced greatly the amount of infection. Further tests may prove that partial control can be obtained by drying the freshly cut seed immediately and rapidly in open crates and by using special precautions to see that proper suberization occurs.

The effectiveness of the knife as a method of disseminating this disease was shown by further studies. An effort was made

TABLE 5

Bacterial wilt and soft rot resulting from contamination of the seed pieces by the cutting knife

Variety	Place	Treatment	Seed pieces	Hills with wilt or rot
				%
Green Mountain	Greenhouse	Contaminated with knife and planted immediately in moist soil	50	60
Irish Cobbler	Ditto	Ditto	50	60
Green Mountain	Field	Ditto	100	40
Ditto	Ditto	Contaminated with knife, allowed to dry immediately and quickly, and planted 3 days after cutting	100	5
Irish Cobbler	Ditto	Contaminated with knife and planted immediately in moist soil	100	38
Ditto	Ditto	Contaminated with knife, allowed to dry immediately and quickly, and planted 3 days after cutting	100	6

to determine the number of successive seed pieces the contaminated knife could successfully inoculate.

For this study a sterile seed-cutting knife was contaminated by cutting through a Spaulding Rose tuber affected with bacterial wilt and soft rot. The contaminated knife was used to cut seed pieces from healthy Green Mountain tubers. Five seed pieces were cut from one or more disease-free tubers before the knife was re-contaminated and used to cut additional tubers in a similar manner. The seed pieces were numbered successively and planted immediately in moist soil in the same order as cut. The results of this experiment are summarized in Table 6.

According to the data in Table 6, the knife was occasionally capable of causing infection of the fifth consecutively cut seed piece. The first and second seed pieces removed were infected in a high percentage of cases. There can be no doubt but that contamination of the seed pieces is one of the methods by which the disease is spread. As will be shown elsewhere, some diseased tubers do not show symptoms of being infected and may serve as an unsuspected source of inoculum for spread by the cutting knife.

TABLE 6

*Transmission by the cutting knife of bacterial wilt and soft rot to successively cut seed pieces**

No. of series	Number of seed pieces removed after each contamination of the knife				
	1st	2nd	3rd	4th	5th
1	X	X	X	0	0
2	X	X	0	0	0
3	0	0	0	0	0
4	0	X	X	X	0
5	X	X	0	0	0
6	X	X	X	0	X
7	X	X	X	0	0
8	0	0	0	0	0
9	X	0	0	0	0
10	X	X	X	0	0
11	0	X	0	0	0
12	0	X	0	X	0
13	0	X	0	0	0
14	X	X	X	0	0
15	X	X	X	0	0
16	X	X	0	0	0
17	0	0	0	0	0
18	X	X	0	0	0
19	X	0	0	0	0
20	X	0	0	X	0
Total % infected	65	70	35	15	5

* The symbol X denotes positive infection that was apparent in the resulting tuber progeny.

VALUE OF PLANTING UNCUT SEED TUBERS FOR THE CONTROL OF BACTERIAL WILT AND SOFT ROT

The fact that bacterial wilt and soft rot may be disseminated by the seed-cutting knife and by contamination of the cut seed pieces has suggested that whole tubers be used for planting purposes if control is desired. The data obtained in Maine pertaining to this phase of the problem are summarized in Table 7.

The data in Table 7 show that planting whole tubers may reduce the amount of the disease that occurs in the field. The disease obviously is not eliminated from the seed stock but is prevented from being spread by the cutting knife and by contamination in handling. The use of whole seed has other advantages than aiding in the control of the wilt disease. It reduces losses from missing hills, especially during seasons unfavorable for the rapid healing of cut seed, and may also reduce the amount of blackleg.

TABLE 7

Comparison of wilt and soft rot in whole-tuber and cut-seed stocks

Variety	Bacterial wilt and soft rot occurring	
	Whole tuber	Cut seed
	%	%
Katahdin	1	20
Ditto	1	8
Ditto	Trace	1
Spaulding Rose	2	5

INEFFICIENCY OF EXAMINATION OF THE CUT SEED TUBERS AS A METHOD FOR THE ELIMINATION OF BACTERIAL WILT AND SOFT ROT

The question has arisen as to whether this disease can be eliminated or reduced by a careful examination of the seed tubers during the seed-cutting operation. Growers commonly believe that a critical examination of the tubers while being cut will reveal the disease and that those affected can then be discarded.

Diseased tubers that are apparently healthy may show, on

being cut, a yellowish discoloration in the vascular bundles. A crumbly and yellowish material, described previously, oozes from the vascular region when the tuber is squeezed in the hand. Such tubers break or become cleft at the vascular ring when pressure is applied. Some tubers may show no discoloration and still may break at the vascular system thus showing they are diseased. The plants grown from seed tubers manifesting any of these symptoms produce plants affected with wilt and soft rot.

A seed stock having wilt and soft rot was cut and examined in an attempt to eliminate the infection. Each tuber was cut with a sterilized knife and placed in one or another of three lots based on the symptoms in the vascular system. Tubers suspected of having wilt were in one lot, those that showed discolored vascular bundles but did not appear to be infected were included in another lot, and those that were free from discoloration and apparently healthy were included in a third lot. These three lots were planted and the diseased plants noted. The test was repeated with a second seed stock. The results are summarized in Table 8.

According to the data in Table 8 it is impossible to eliminate all of the infected tubers by a critical examination during the seed-cutting process. Some tubers obviously are diseased and can be discarded. Some infected tubers, however, show no symptoms of the disease. Other tubers have symptoms so slight that they probably would not be noted by the seed cutters. Furthermore, most seed cutting is done in haste and no time is permitted for an examination of individual tubers. These facts make it seem impractical to attempt to eliminate wilt and soft rot by the examination of seed stocks while they are being cut.

TABLE 8

*Percentage of plants having bacterial wilt and soft rot, grown from seed tubers having different degrees of discoloration or decay in the vascular bundles**

Stock	Vascular bundles affected with decay	Vascular bundles discolored	Vascular bundles not discolored
	%	%	%
1	100	9	8
2	100	2	7

* Each lot of seed consisted of 300 seed tubers.

Roguing for the Control of Soft Rot and Wilt

The practice of roguing does not seem to be an effective method of controlling bacterial wilt and soft rot in Maine. Some growers in this State have practiced rigid roguing methods and have not succeeded in eliminating the trouble although they have prevented rapid spread. The late appearance of the disease and the difficulty in detecting the affected plants make roguing seem impractical.

On September 15, 1937, the writer removed 44 per cent of the plants from a seed plot, as evidently diseased. Eight days later 10 per cent of the remaining plants were affected and the accumulated percentage continued to increase until the remaining plants were killed by frost. Often many plants that are diseased do not show the symptoms. One particular field was considered to be free from wilt. Late in the season one suspicious looking plant was found. On being dug and examined, this hill was found to have its tubers affected, as were also the 16 following hills in the same row downhill, though they appeared to be healthy. Likewise tubers that appear normal on the outside may have a rather high percentage of disease. For example, in 1938, 17 tubers that had slight vascular discolorations but otherwise were normal were planted for observation. These tubers produced plants that were normal appearing the entire season. The plants were harvested just prior to a killing frost and the tubers examined. Fifteen of the 17 plants gave tubers with varying degrees of tuber decay. This lot was isolated and the disease must have come from the seed tubers. This also is another example of apparently healthy hills being diseased.

The data in Table 3 show that wilt and soft rot is readily disseminated in the field and that a high proportion of the healthy plants close to diseased plants will become infected. This fact and the data that have just been given indicate that roguing and other seed plot methods may not be very helpful in giving control.

Control Measures

The only practical method of controlling wilt and soft rot is by the use of disease-free seed. It will be necessary to conduct very rigid field inspections and eliminate as seed sources all stocks that show even a trace of this wilt. The writer thinks that it will

be impossible for growers to select disease-free seed from fields of infested stock. The disease is sometimes difficult to detect and often neither the plants nor the tubers show symptoms when infected.

The effectiveness of the use of disease-free seed in eliminating wilt is shown by the results obtained by the certification service in 1937 and 1938. In 1937, 28 per cent of the acreage of the Spaulding Rose variety entered for seed certification was rejected because of bacterial wilt, 1106 acres being entered and 310 rejected. In 1938 only one small field of this variety was rejected because of this disease. The stock with which this field was planted was known to have had wilt in 1937 and should not have been used for seed purposes. Thus, although the disease is threatening, it apparently can be controlled.

Planting whole tubers or allowing the cut seed to dry soon after it is cut will prevent some spread. It is also quite likely that treating the cut seed will be of some aid as a control measure. It is advisable to disinfect the storage bins, barrels, and other equipment thoroughly if they have come in contact with tubers having the disease.

Planting healthy seed stocks adjacent to stocks having the disease should be avoided. The writer knows of no fields that have escaped becoming contaminated when grown adjacent to diseased fields.

It will be a difficult task to check the progress of this disease, even if the known control measures are taken. It may become necessary to attempt to develop new varieties that are highly resistant or immune.

SUMMARY

The bacterial wilt and soft-rot disease is becoming of major importance in some parts of Maine, and has been reported as occurring in other potato-growing areas in the United States and Canada. The loss from this disease in Maine was estimated at $32,000 in 1937 and nearly $80,000 in 1938.

There are characteristic foliage and tuber symptoms. The disease apparently is not soil borne in Maine and is perpetuated from year to year in the seed tubers. The increase of the disease under field conditions is often very rapid and seed stocks with a trace of infected plants may develop a high percentage of the disease the following year, with large losses resulting.

Experiments have shown that bacterial wilt and soft rot may be disseminated in the field. The spread, however, was not extensive beyond the first row. The method by which this field spread occurs is not known. The spread is more extensive down a hillside slope.

Contamination of freshly cut seed by contact with decayed tubers will spread wilt and soft rot. Seed tubers that were bruised and contaminated with decay, and then put in storage for the winter, developed disease in 7.6 per cent of the plants the following season. The amount of disease was only 1 per cent when the contaminated tubers were not bruised prior to storage.

The cutting knife is an effective agent in spreading the disease. A knife contaminated by being passed through an affected tuber was found capable of transmitting the disease even to the fifth seed piece cut thereafter. The amount of infection was reduced by drying the seed pieces quickly as soon as they had been cut.

The disease was not eliminated by a careful examination of the seed during the cutting operation, nor was it controlled by roguing and seed plot methods. The amount of bacterial wilt and soft rot was reduced by planting whole seed tubers, and this practice may be of some value in reducing excessive losses.

The only practical method of control is by the exclusive use of disease-free seed. Growers should also avoid planting stocks, if intended for seed purposes, in close proximity to fields of potatoes that have bacterial wilt and soft rot.

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